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A.& A.E.E. Arm/Res/35

MINISTRY OF SUPPLY

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT

BOSCOMBE DOWN

REPORT ON THE DESIGN, MANUFACTURE AND TESTING OF THE A.A.E.E. RECORDER TYPE 100

by

R. J. BICKFORD, GRAD.I.E.E.

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Report No. A.A.E.E./Arm/Res/35

2 4 MAR 1952

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A.& A.E.E. Ref: AAEE/5923/8

Summary

This report gives the requirements and describes the design of the A.& A.E.E. Type 100 recorder which uses 35 m.m. Teledeltos paper as the recording medium. The recorder was specially designed for determination of rates of fire of multi-gun installations for use in fighter aircraft, where little space is available for instrumentation.

Brief reference is made to a larger 24 channel version to record delay of bomb release units in bomber aircraft.

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1. Introduction

1.1 The A.& A.E.E. Recorder Type 100 was primarily designed to satisfy a requirement for the determination of rates of fire of multi-gun installations of fighter aircraft in flight. As far as is known the only other instrument specifically designed for this task is the Cambridge Instruments Chronograph which records the rates of fire of three guns together with a time base. (Reference RAE Tech Note Arm 383). This instrument has certain limitations in size and duration of record, number of channels and in spooling of recording celluloid. An indication of the accuracy which may be expected from the single channel Cambridge Instruments Blast recorder is given in Table 1 (Appendix 1).

1.2 The requirements of the Type 100 recorder are that:-

(a) It should be capable of installation in the latest new fighter aircraft, where the space available for recorders is extremely small.

(b) The record should be available for immediate inspection.

(c) The unit should be able to record the rates of fire of both 20 m.m. and 30 m.m. guns as accurately as possible considering (a) above.

1.3 After consideration had been given to the various methods for recording events, it was decided to design the recorder along the following lines:-

(a) The recording media to be teledeltos paper which provides an immediate permanent record.

(b) The unit should be as small as practical and draw both H.T. and L.T. from the normal aircraft supplies.

(c) It should record events from contacts or switches on 4 channels up to a rate of 1400 per minute per channel.

(d) Timing marks should be applied to both edges of the paper by a vibrating reed with a stability of better than 1% if temperature changes are kept to a minimum.

2. Description and installation

2.1 Teledeltos paper has a grey chemical deposit containing lead thiosulphate on the upper surface and a metallic deposit on the underside. If sufficient voltage is applied across the two surfaces of the paper the upper surface will change colour to black immediately under the marking pen and if the paper is moving a fine line will be drawn on it.

2.2 The main unit is approximately 9" x 5" x 4½" and is mounted on an anti-vibration tray in an accessible position in the aircraft, preferably inside the pressure cabin. A small control box, mounted within sight and reach of the pilot, containing two switches operates the recorder. Both the units are connected each by a single cable to a terminal block or junction box. Normal aircraft supplies, i.e. 24 volts D.C. and 115 volts 400 c/s from the inverters, are also connected to the junction box. The recorder can be operated completely automatically from the gun safety switch and the firing button if this method is preferred.

3. Circuit sequence

3.1 When the master switch is placed in the "on" position the master switch warning light is illuminated and relay R2 (Fig.3) closed to put 115 volts 400 c/s on to the primary winding of the main transformer, and D.C. on to the heater of the 2D21, (CV 797) timing thyratron (Fig.3).

/3.2.....

3.2 The armature of the starter coil, deflects the timing reed so that when the starter coil is energised, also by the master switch, the reed, now released, commences to vibrate and is maintained by the reed coil supplied in parallel with the starter coil. The reed contact controls the thyratron and an anode pulse transformer provides the volts for the time marker pens.

3.3 Pressing the record switch energises relay R_1 which starts the recording motor, and completes the centre tap line of the H.T. transformer to L.T. positive. The four gun relays R 3, 4, 5 and 6 are supplied in series with 4 gun switches fed from the positive side of the motor. As each round is fired the gun switch is actuated and 'makes' the gun relay contacts, and a positive from the cathode of the 5Z4 rectifier is put on to the pen and returned through the paper to the marking tray, which is at earth potential, thus producing the record. L.T. positive is strapped to earth by a 500 ohm resistor. This arrangement obviates the necessity of isolating the marking tray from earth. In the case of the 30 m.m. Aden gun it is movement of the barrel group relative to main cradle and for the 20m.m. Hispano gun it is the relative movement of the magazine carrier and the gun body that actuates the gun switch pick up unit. This can be either a micro-switch or a specially designed contact switch.

3.4 The reed contacts short the grid of the thyratron to earth, the resultant anode pulse is stepped up 3 : 1 and paralleled on to the two timing pens.

3.5 It should be noted that the master switch controls both H.T. and L.T. supplies and if the record switch is inadvertently selected with the master switch off recording paper will not be wasted. A period of two minutes should elapse after the master switch is operated before the record is made to allow the reed to stabilise and the valve heaters attain normal working temperature.

3.6 It is also advisable to operate the record switch two or three seconds before firing and to switch off two or three seconds after the end of each burst; this is to divide the record clearly into bursts of fire.

4. Recording paper and speed

4.1 The Type 100 recorder is designed for use with rolls of teledeltos paper 35 m.m. wide, outside diameter $2\frac{1}{4}$" containing approximately 80 feet of paper. The paper is run through a differentially tensioned system of rollers which ensures constant speed and obviates any tendency to misalignment. The paper speed is approximately 10 inches per second and the driving motor of the 1st prototype is an American type taken from a G.S.A.P. camera running at 10,000 r.p.m. The production recorder, will however, be fitted with a small British motor which will entail some modifications in the gear train. The take-up spool is rotated by a spring drive and can be removed from the recorder in a few seconds.

5. Tests

5.1 The first prototype model contains no provision for maintaining the reed at a constant temperature. However it was decided to test the unit to determine the frequency variations with temperature and altitude in the stratosphere chamber, before considering the fitting of thermostatically controlled heaters.

These results are shown in Table 2 (Appendix 1).

5.2 The air testing of this unit was carried out on a Vampire Night Fighter (Mk.10) and after some initial difficulties with pen pressures, the rate of fire of the 4 x 20 m.m. Hispano guns with 100 rounds per gun was successfully recorded. A part of this record is reproduced in Fig. 10. For airborne work it is most important to use an anti-vibration tray (Fig. 9), otherwise the vibration induced by the gun-firing may cause fluctuations in the frequency of the reed.

/5.3....

5.3 As part of the testing for reliability, the Type 100 recorder has been used as the standard method of determining rates of fire of new guns on ground stands at this Establishment and serviceability up to the present time has been 100% for a total of approximately twenty records.

6. Calibration and computation

6.1 For the determination of accurate rates of fire it is advisable to calibrate the instrument immediately before or after use, on a test rig. This rig is exactly similar to an aircraft installation, but the gun switch inputs are paralleled and fed from a Tinsley 50 cycles/sec. timing fork. This frequency is well within the capabilities of the gun-firing relays used in the recorder (STC type 4181 CM).

6.2 The calibration record will indicate the correct setting of the relay contacts if the four traces commence and terminate at the same instant. It is possible to adjust variations in operating times of these relays to 2 or 3 millisecs.

6.3 The calibration of the reed, obtained from the test rig records is prepared in the manner shown in Appendix 2.

7. Recommendations

7.1 The following modifications will be incorporated in the production version of this recorder. These are:-

1. British type motor to replace American item.

2. Reduction in size of H.T. transformer and further secondary winding for the heater of the 2D21.

3. Inclusion of a miniature $\frac{1}{2}$ second clock recording on one edge of the teledeltos paper, the reed continuing to record on the other. This change makes it possible to check the frequency of the reed throughout the actual recording.

4. Ball races in preference to plain bearings on gear shafts.

5. Substitution of fibre gears for metal gears.

8. Recorder for bombing trials

8.1 A larger version of the A.A.E.E. Type 100 recorder to be known as the A.A.E.E. Type 102 recorder has just been developed and the first prototype is nearing completion. This unit records events from 24 channels on 3 inches wide teledeltos paper. Complete power requirements are obtained from the aircraft 28 volts D.C. input. The complete unit except for the control box measures $11\frac{1}{2}$ x $7\frac{1}{2}$ x 5 inches. Its designed use is for multi-channel recording on bombing trials for measurement of bomb release unit delay times.

Circulation List

D. Arm. R.D. (Air)	4 copies	
D. Inst. R.D.	1 copy	
A.M. D.D. Arm. Eng.	through D. Arm. R.D. (Air)	1 copy
A.M. Arm. 3	" " "	1 copy
R.A.E. Arm.		1 copy
R.A.E. I.A.P.		1 copy
R.A.E. Instruments		1copy
R.A.E. Structures		1 copy
C.E.A.D. Enfield		2 copies
T.P.A.3/T.I.B.1c		75 copies

Appendix 1

Table 1

Comparison of Rates of Fire Recorders

	R of F Rounds/Min.	* Variation from miniature recorder
Cambridge Blast Recorder (clockwork)	651	2.20% Fast
Cambridge Blast Recorder (electric)	667	4.71% Fast
*A.& A.E.E./Hughes Miniature Recorder	637	-

Note

The A.& A.E.E./Hughes 4 channel Miniature graphical recorder was developed by this establishment for kinematic recording. When rates of fire on the ground stand are required it is used in conjunction with a Tinsley 50 cycle/sec. tuning fork, which has an accuracy of 1 part in 10,000.

Table 2

Variation of Reed Frequency with Temperature and Pressure

Temp.	Pressure	f_v
-4°C	Sea	37.1
+5	level	37.5
14	↓	37.5
23		37.2
32		37.8
41		37.9
50		38.8
59		38.0
68	↓	38.1

Height feet	Temp.	f_v
0	19°C	38.7
5,000	↓	39.3
10,000		38.4
15,000		38.8
20,000		38.6
25,000		38.9
30,000		38.5
35,000		38.5
40,000		38.5
45,000	↓	38.6

*Described in Report No. Arm./Res./34.

Appendix 2

Select 10 to 20 inches of the record avoiding the beginning of the record, where the motor has not reached full speed.

Let the number of dashes (for tuning fork) be N_A
Let the number of dots (from reed) be No
Let the length of record containing N_A dashes be L_A cms.
Let the length of record containing No dots be Lo cms.

Then time of tuning fork record = $\frac{N_A}{50}$ seconds

and the average velocity of paper = $\frac{L_A \times 50}{N_A}$ cms/sec.

Therefore the time to record No dots = $\frac{Lo \times N_A}{L_A \times 50}$ secs.

and frequency of vibrating reed, $f_v = \frac{No\ L_A}{N_A\ Lo} \times 50$

The instrument is then removed from the test rig ready for installation in the aircraft.

To determine rates of fire select a portion of the airborne record as before, remembering to avoid the start of the burst.

Proceeding as above the rate of fire is:

$$60 \frac{N'_A}{N'o} \frac{L'o}{L'_A} \times f_v \text{ rounds per minute.}$$

Where N'_A is the number of dashes in L'_A cms. (gun record)

and N'o is the number of dots in L'o cms (timing record)

If however it is only required to determine approximate rates of fire, count the number of dashes occurring in one second (i.e. in a length of record containing f_v dots) and this value multiplied by 60 will give an approximate rate of fire. Under these conditions it will not be necessary to calibrate the recorder more than once in 8 or 10 flights.

For straightforward comparisons, where only relative rates are required between say different gas plugs or types of ammunition, the above calibration will be unnecessary and the rates may be expressed as a percentage of the rate of the control gun.

KEY TO FIGURE 1

A. Marking Pens

B. 12 pin Plessey Mark 4 plug

C. Marking tray

D. Differentially tensioned roller

E. Spring drive to take-up spool

F. Take-up spool

G. Recording paper (35 m.m. Teledeltos)

H. Motor driving rollers by gear train

J. Drive roller

K. Feed spool (with detachable side)

L. Transformer (400 cycles/sec. step up 3 : 1)

M. Maintaining coil

N. Vibrating reed

O. Marking pens (in raised position)

P. Rectifier 5Z4

Q. Gun switch relays

R. Thyratron anode pulse transformer

S. Limiting resistors for marking pens

T. Reservoir condenser for H.T. smoothing

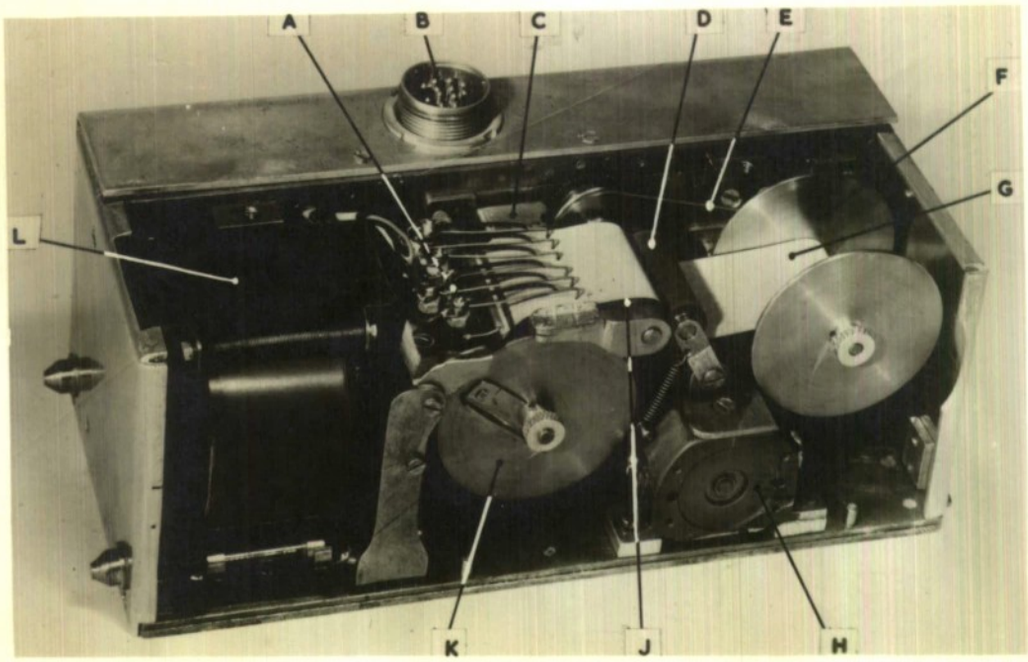
U. Thyratron 2D21

V. Record switch relay

W. Starter coil

X. Master switch relay

Y. Take-up spool



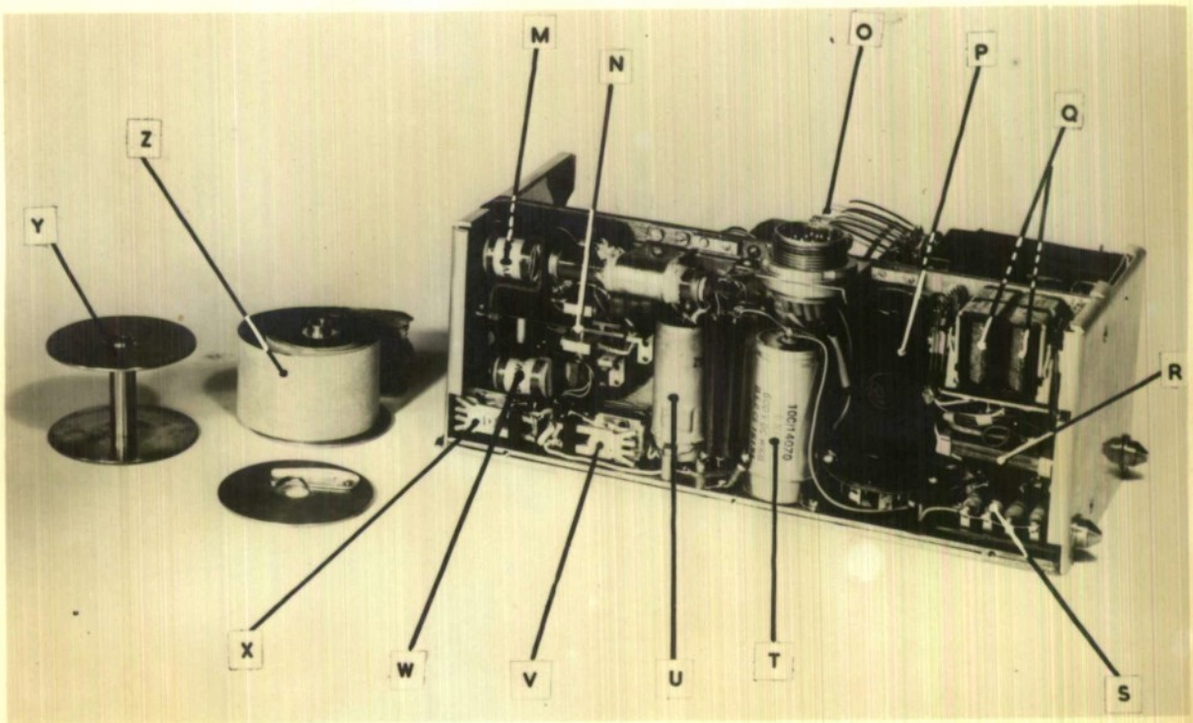


FIGURE 1

A.& A.E.E. NEG. Nº 15780

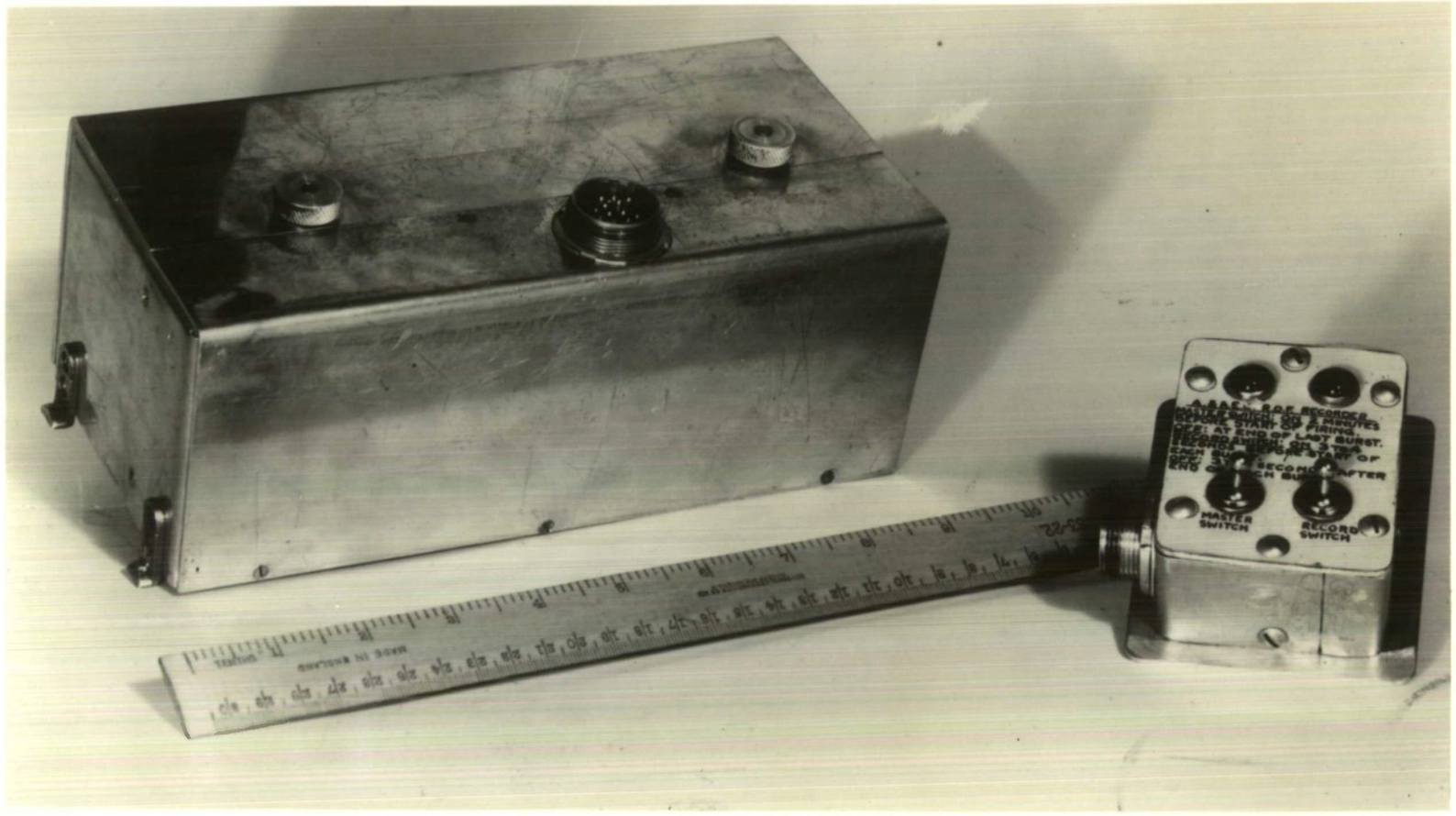
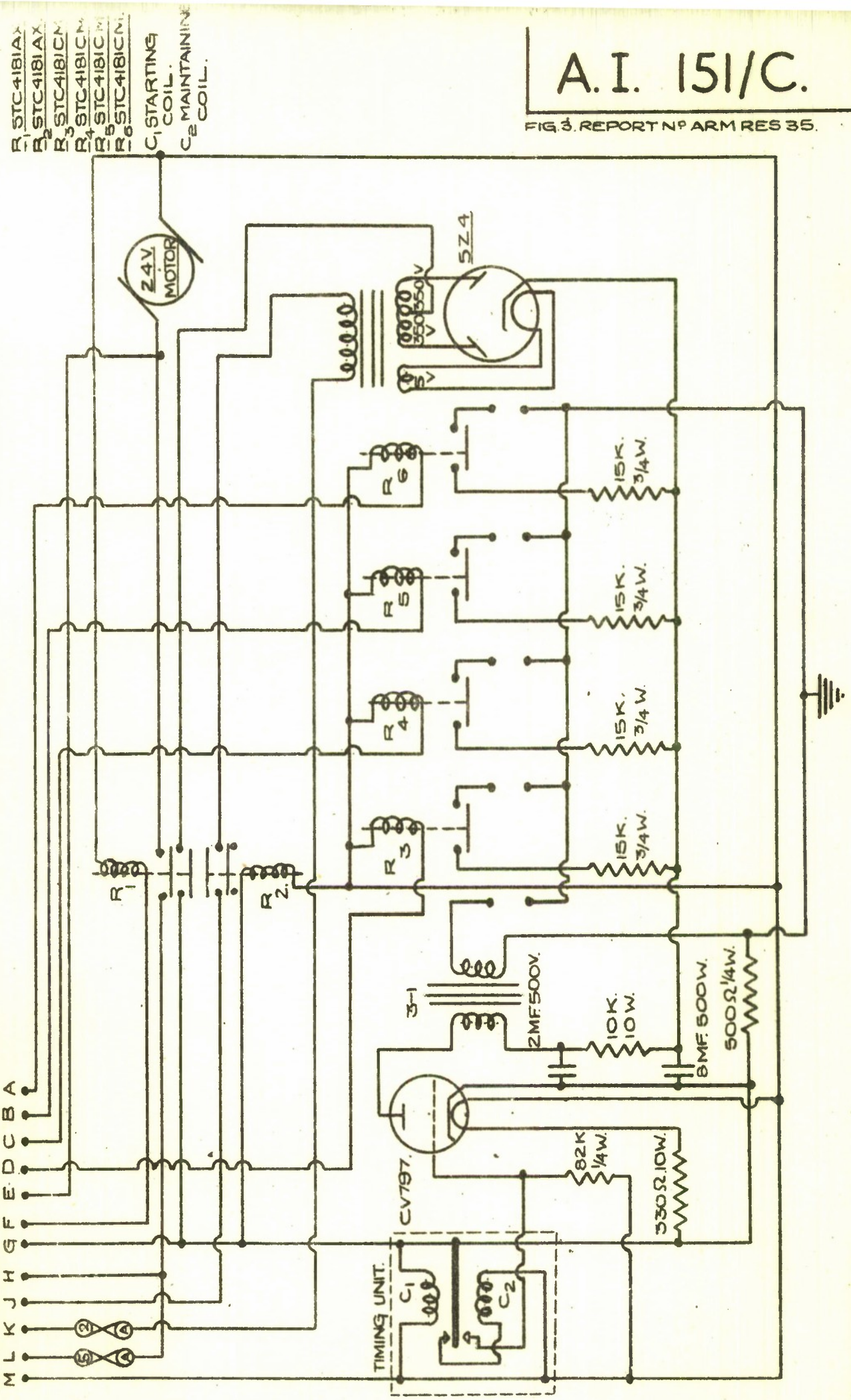


FIGURE 2.

A.& A.E.E. NEG. Nº 15780

A.I. 151/C.

FIG. 3. REPORT Nº ARM RES 35.



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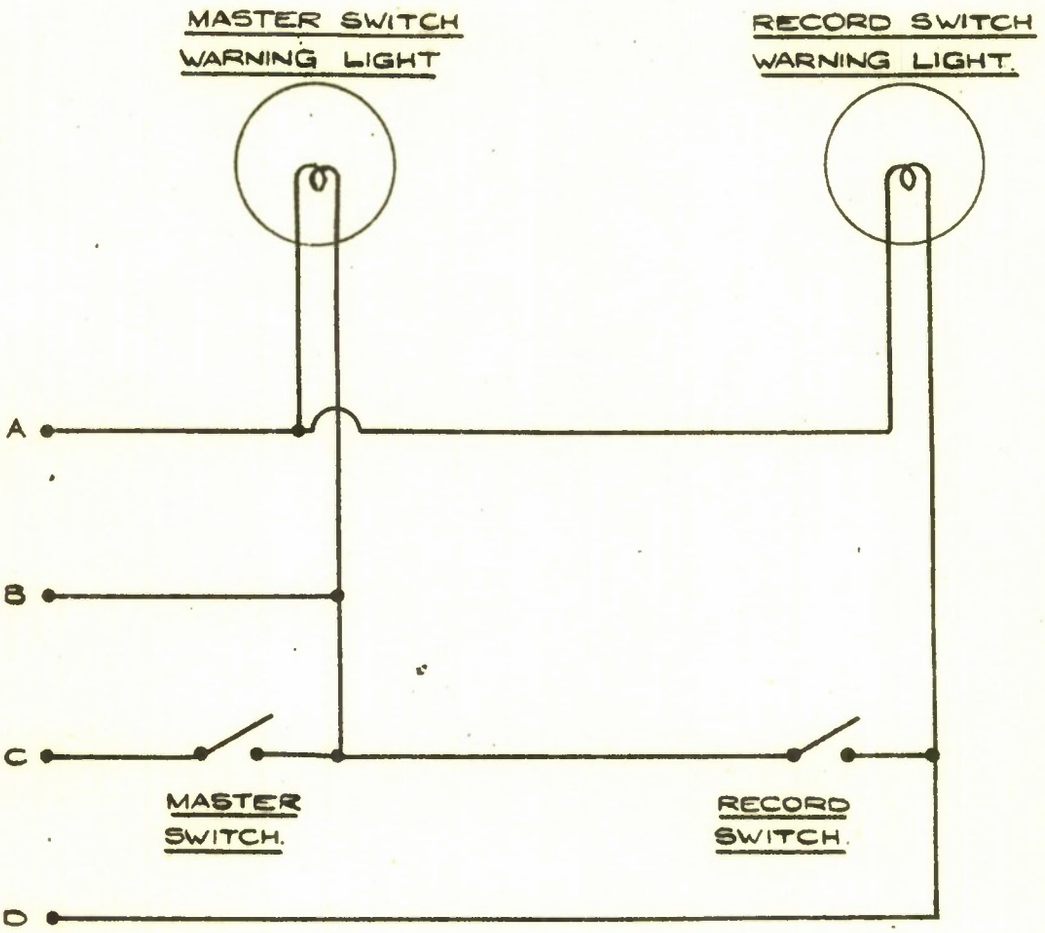
CIRCUIT DIAGRAM. RECORDER, A.& A.E.E. TYPE 100. (RATE OF FIRE)

A.I. 151/C

ISSUE Nº	
ALTN Nº	
DATE.	

A.I.-152/C

FIG.4. REPORT Nº ARM RES 38.



PLUG, REF. 10H/19084, TO RECEIVE
SOCKET, REF. 10H/19083.

ISSUED BY A.& A.E.E. BOSCOMBE DOWN. | DR. | TR. D.L. | CH. | APP. | 14-12-57 for S.of A.

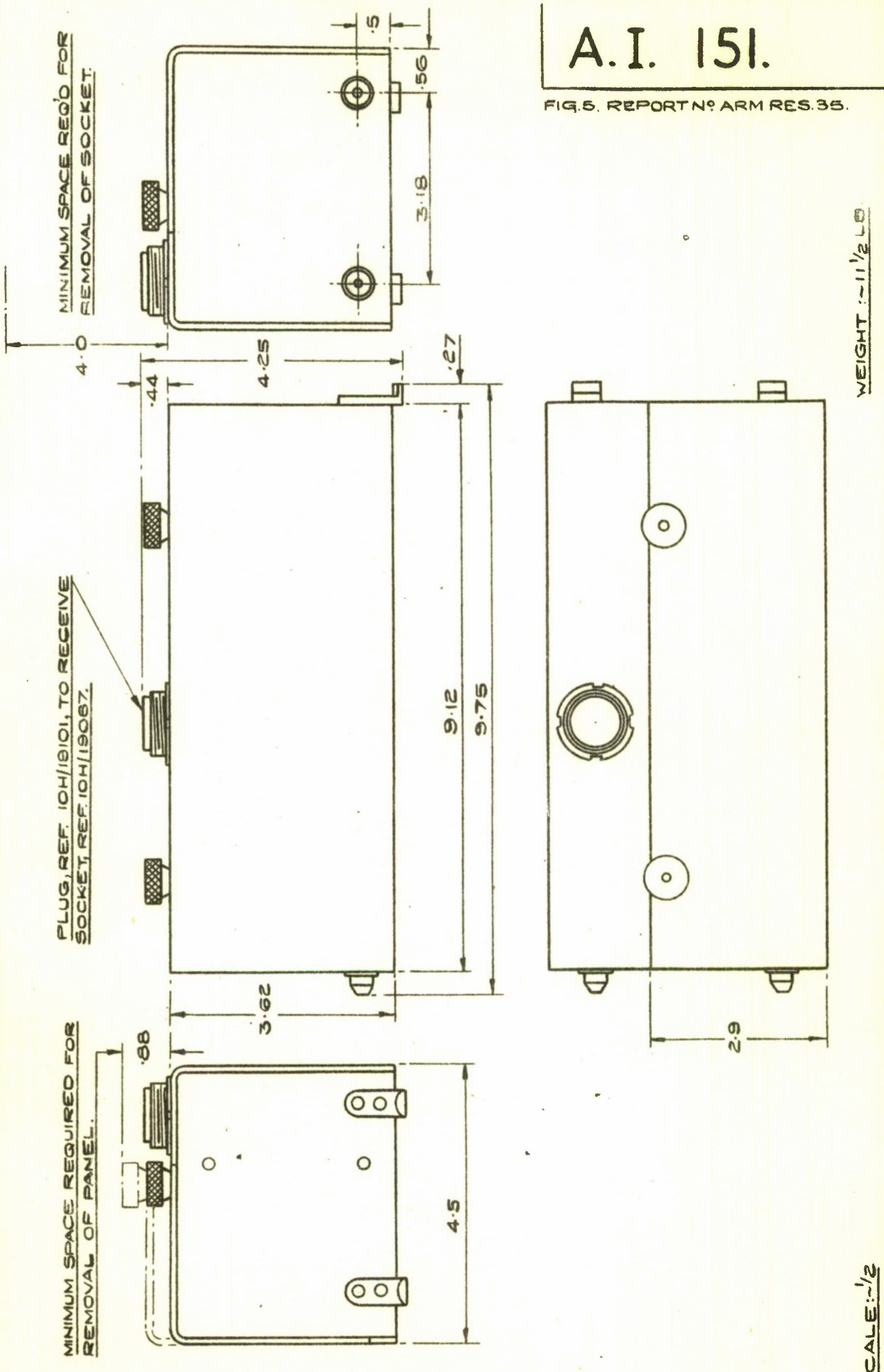
A.I.-152/C.

CIRCUIT DIAGRAM. CONTROL BOX FOR RECORDER, A.& A.E.E. TYPE 100.

ISSUE Nº																	
ALT.N Nº																	
DATE																	

A.I. 151.

FIG.5. REPORT Nº ARM RES.35.



WEIGHT :- 11½ LB.

SCALE :- ½

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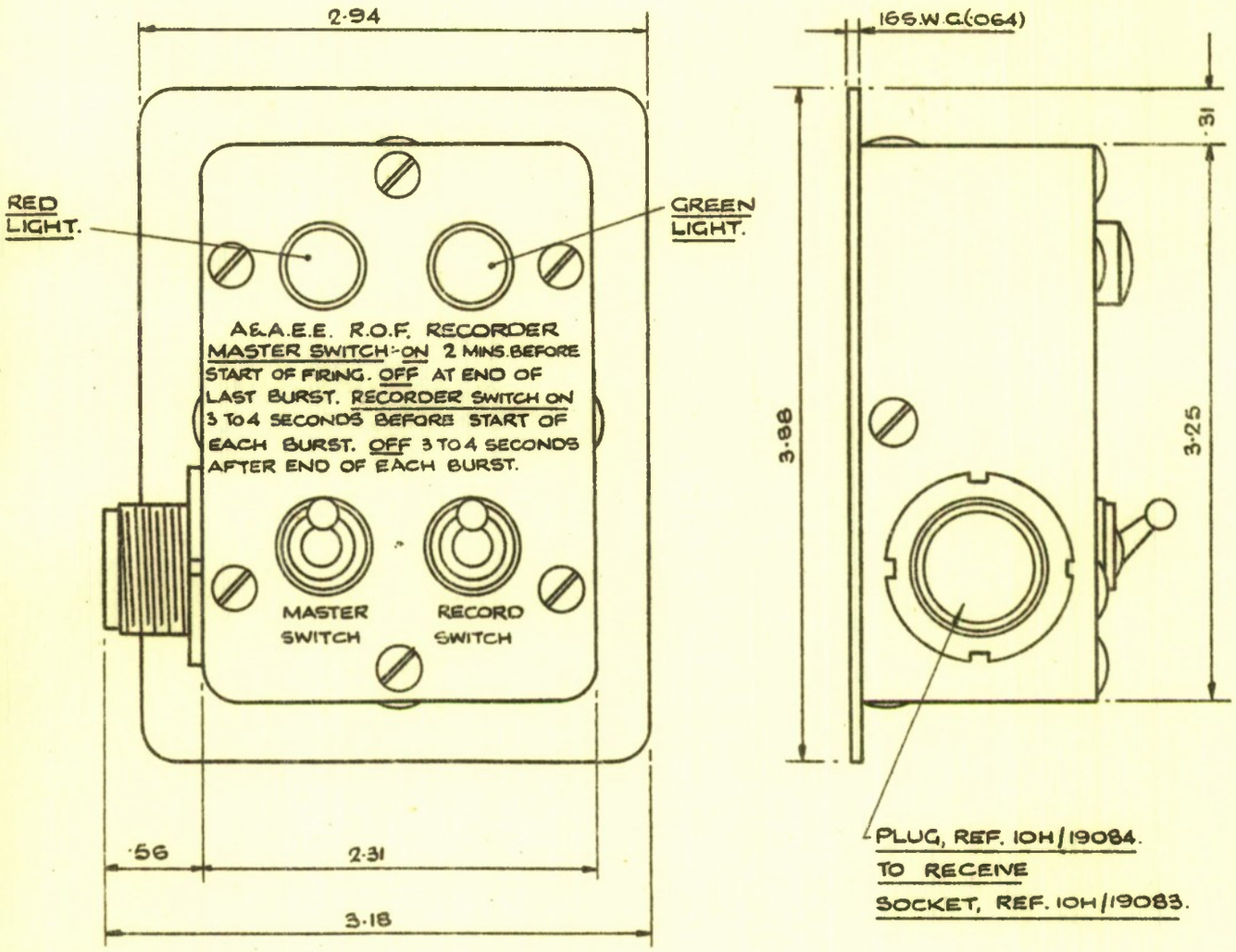
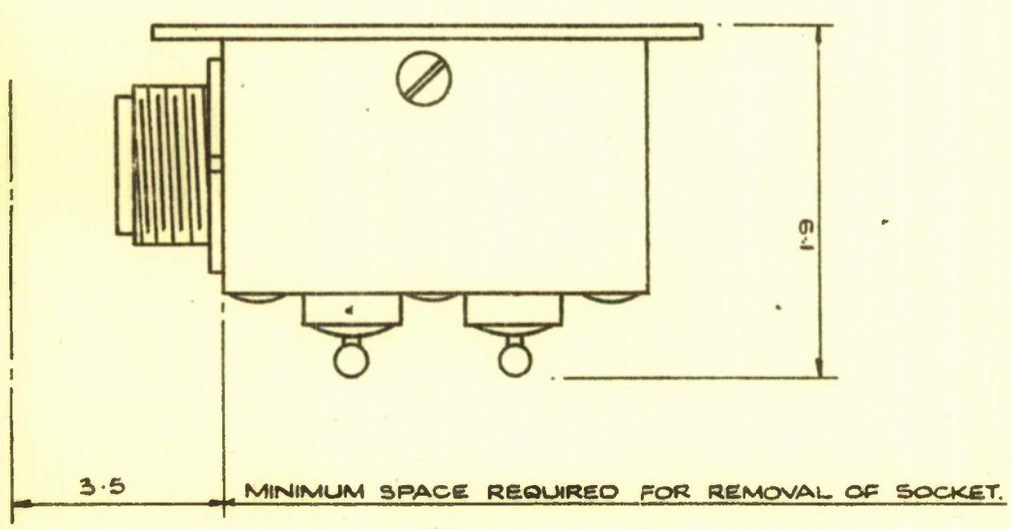
RECORDER, A.& A.E.E. TYPE. 100. (RATE OF FIRE.)

A.I. 151	ISSUE Nº																
	ALTN Nº																
	DATE.																

A.I. 152.

FIG. 6. REPORT Nº ARM RES. 35.





SCALE:- 1/1

WEIGHT:- 8 OZ.

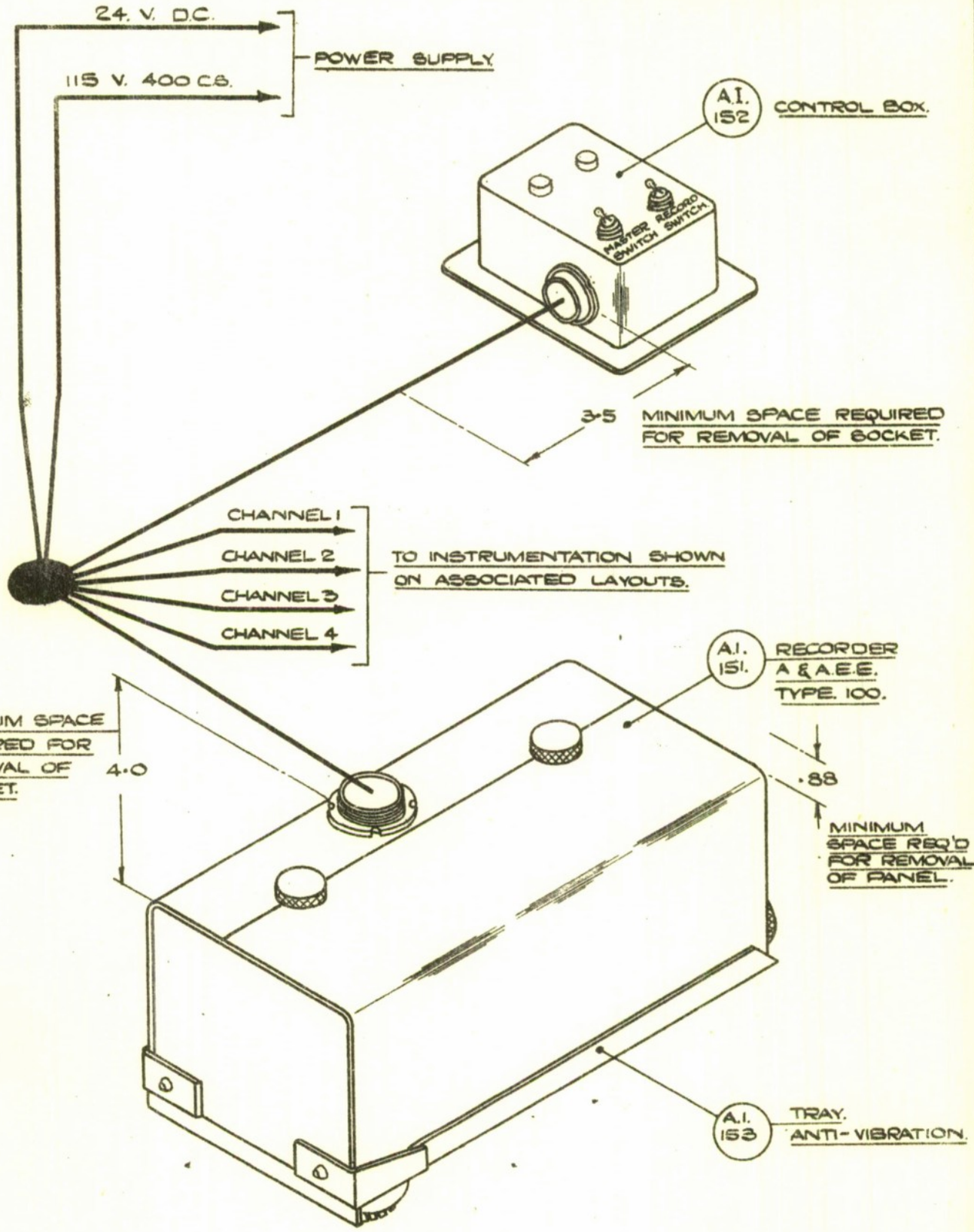
CONTROL BOX FOR RECORDER A&A.E.E. TYPE 100. (RATE OF FIRE)

ISSUE Nº																	
ALTN. Nº																	
DATE																	

A.I. 152. | ISSUED BY A&A.E.E. BOSCOMBE DOWN. | DR. | TR. S.M. | CH. | APP. | for Sof A. | 14·2·51

A.I. - 21A.

FIG. 7. REPORT Nº ARM RES. 35.



SCHEMATIC LAYOUT OF EQUIPMENT FOR RECORDING RATE OF FIRE (4 CHANNEL.)

ISSUE Nº.																
ALT. Nº																
DATE.																

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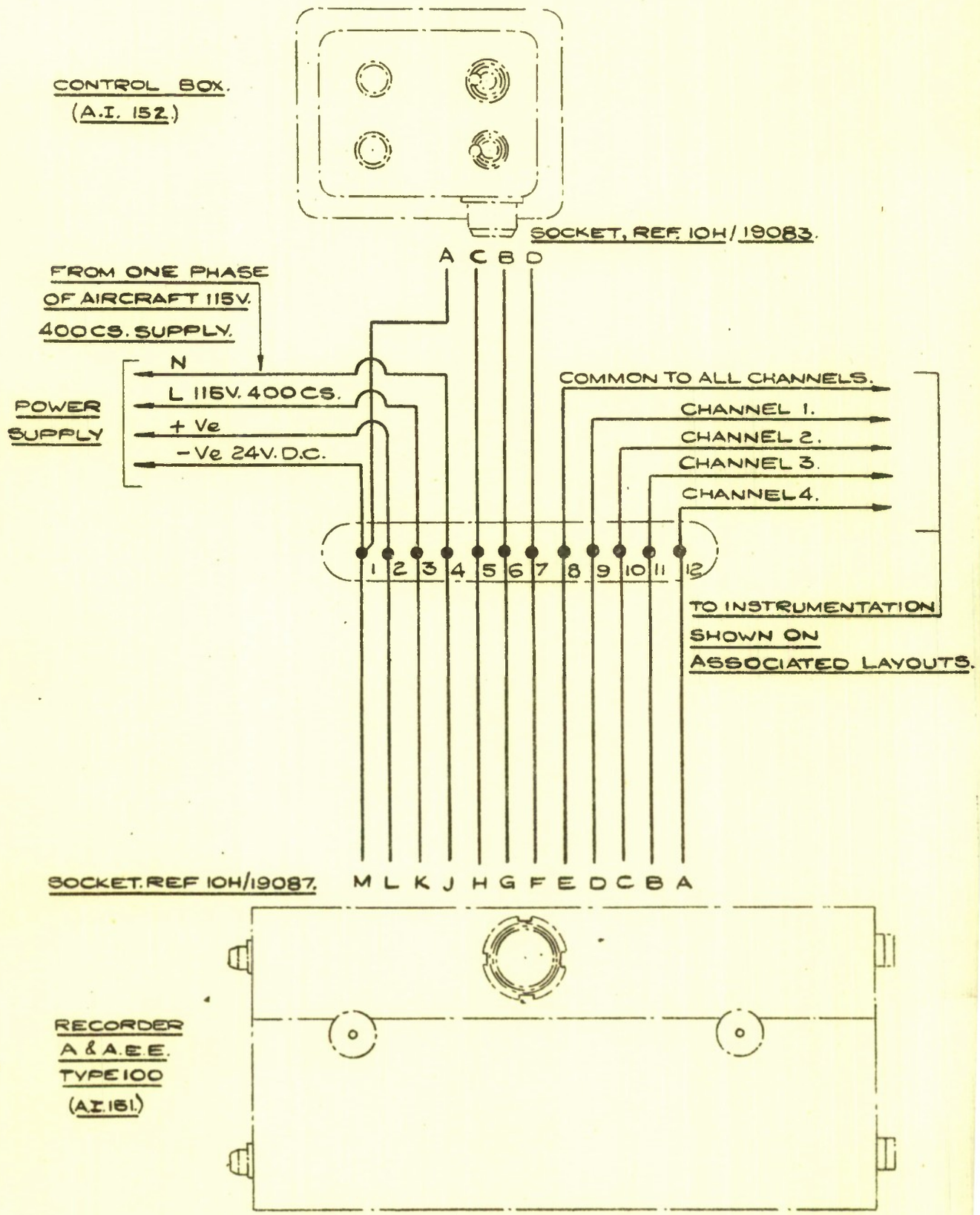
A.I. - 21. A.

A.I.-21A/W

FIG. 8. REPORT Nº ARM RES. 35.



REF. A.I.-21A FOR SCHEMATIC LAYOUT.

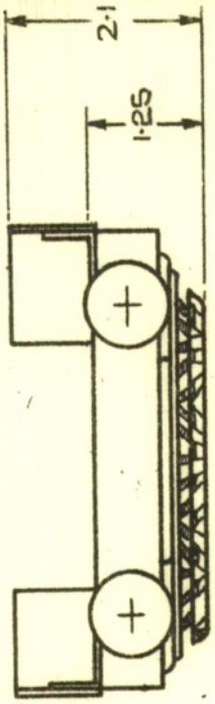
WIRING DIAGRAM. EQUIPMENT FOR RECORDING RATE OF FIRE. (4 CHANNEL.)

ISSUE Nº.																
ALTN Nº																
DATE.																

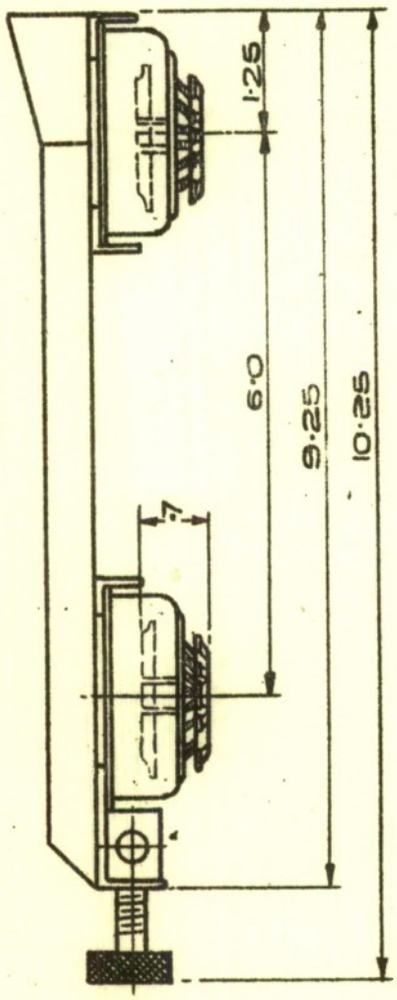
A.I.-21 A/W | ISSUED BY A. & A.E.E. BOSCOMBE DOWN. | DR. | TR.D.L. | CH. | APP | for S. of A. | 14.12.51

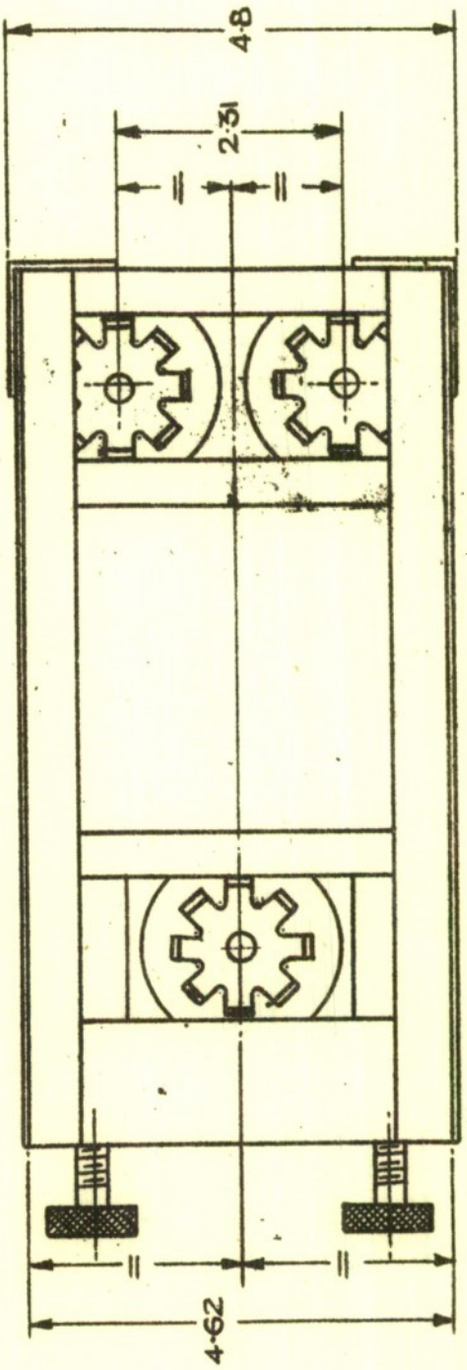
A.I. 153.

FIG 9. REPORT Nº ARM. RES. 36.



ANTI-VIBRATION MOUNTINGS. REF 10 A/17619.





3 HOLES FOR 1/4 DIA. BOLTS.

WEIGHT:-

SCALE 1/2

A.I. 153	ISSUED BY A&A.E.E. BOSCOMBE DOWN.	DRAWN.	TR. P.A.	CH.	APP.	4.3.52
					for Sof A	

TRAY, ANTI-VIBRATION, FOR RECORDER, A&A.E.E., TYPE 100.

ISSUED Nº																
ALTN Nº																
DATE																

TYPICAL RECORD MADE AT 300 KNOTS, 2,000 FEET. LYME BAY RANGE.

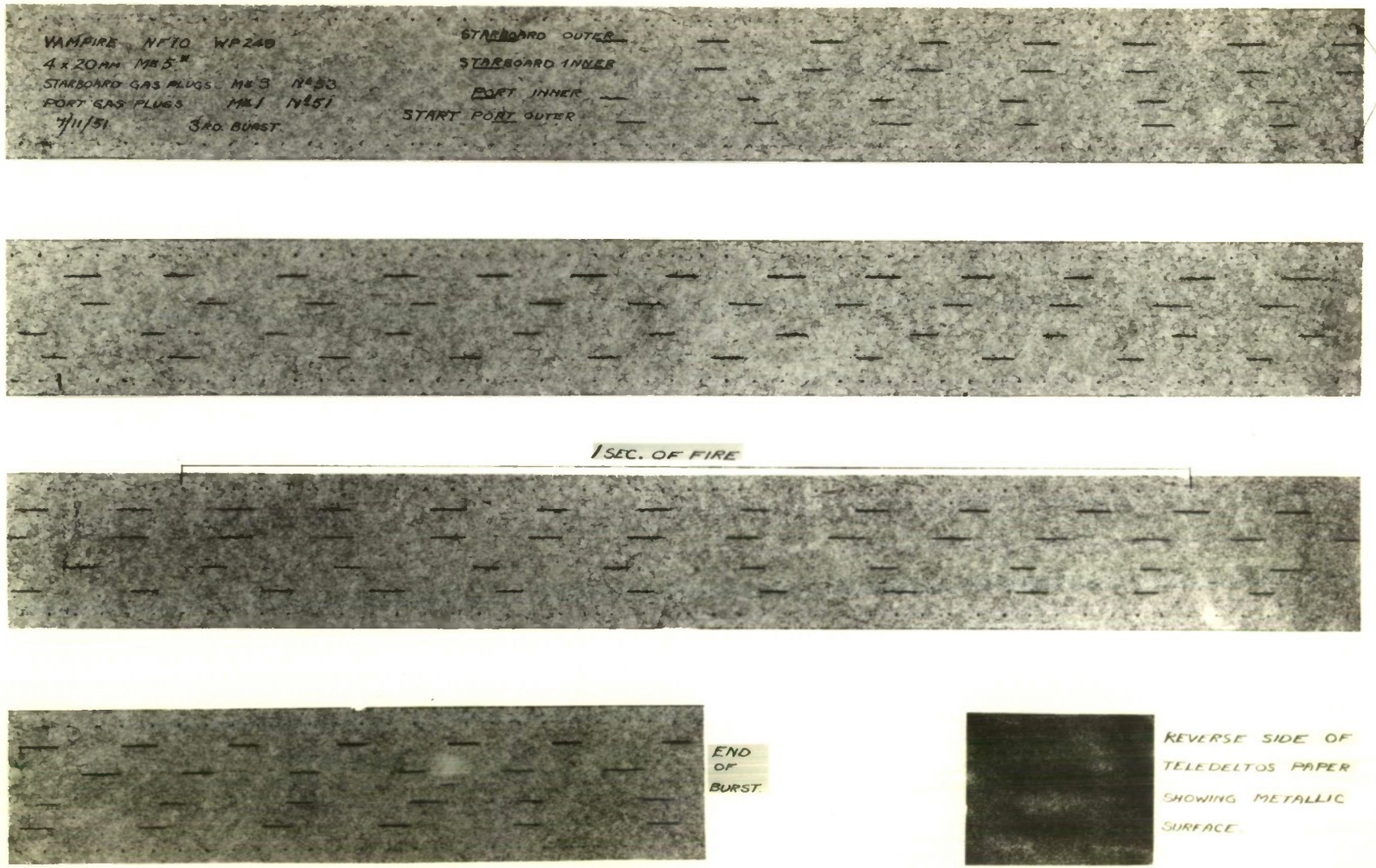


FIGURE 10

A.& A.E.E. NEG. No 15780

[dstl]

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Knowledge Services
[dstl] *Porton Down*
Salisbury
Wilts
SP4 0JQ
Tel: 01980-613753
Fax 01980-613970

Defense Technical Information Center (DTIC)
8725 John J. Kingman Road, Suit 0944
Fort Belvoir, VA 22060-6218
U.S.A.

AD#:
Date of Search: 16 February 2007

Record Summary:

Title: Report of the design, manufacture and testing of the AAEE recorder type 100
Covering dates 01/01/1952 - 31/12/1952
Availability Open Document, Open Description, Normal Closure before FOI Act: 30 years
Former reference (Department) A&AEE/ARM/RES 35
Held by The National Archives, Kew

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